Analysis of Plume Impingement Effects from Orion Crew Service Module Dual Reaction Control System Engine Firings

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Plume impingement effects on the Orion Crew Service Module (CSM) were analyzed for various dual Reaction Control System (RCS) engine firings and various configurations of the solar arrays. The study was performed using a decoupled computational fluid dynamics (CFD) and Direct Simulation Monte Carlo (DSMC) approach. This approach included a single jet plume solution for the R1E RCS engine computed with the General Aerodynamic Simulation Program (GASP) CFD code. The CFD solution was used to create an inflow surface for the DSMC solution based on the Bird continuum breakdown parameter. The DSMC solution was then used to model the dual RCS plume impingement effects on the entire CSM geometry with deployed solar arrays. However, because the continuum breakdown parameter of 0.5 could not be achieved due to geometrical constraints and because high resolution in the plume shock interaction region is desired, a focused DSMC simulation modeling only the plumes and the shock interaction region was performed. This high resolution intermediate solution was then used as the inflow to the larger DSMC solution to obtain plume impingement heating, forces, and moments on the CSM and the solar arrays for a total of 21 cases that were analyzed. The results of these simulations were used to populate the Orion CSM Aerothermal Database.

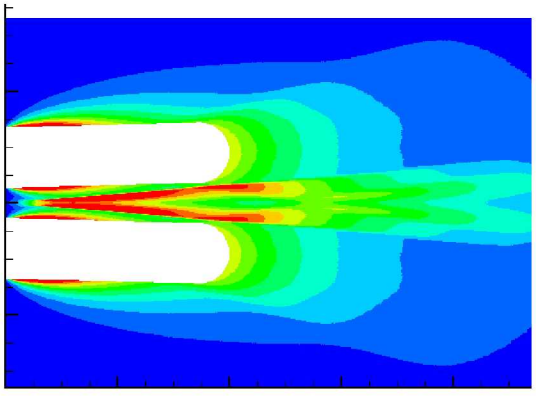

Figure 1: Dual Plume Shock Interaction

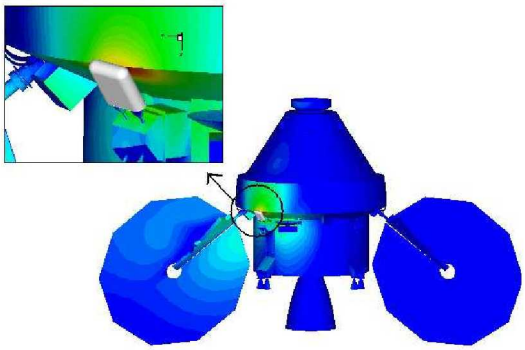

Figure 2: Plume impingement on CSM